Rehospitalization After Combat Injury

Brendan D. Masini, MD, Brett D. Owens, MD, Joseph R. Hsu, MD, and Joseph C. Wenke, PhD

Background: Frequency of rehospitalization and associated resource requirements are unknown for combat casualties. Differences may also exist in readmission rates for injuries to separate body regions. This study investigates rehospitalization of combat casualties with a hypothesis that extremity injuries cause the greatest number of readmissions and require the greatest resources to treat.

Methods: A Department of Defense database was queried for hospital admissions of a previously published cohort of service members initially wounded in Iraq and Afghanistan between October 2001 and January 2005. Cohort admission data were collected from October 2001 to February 2008. Body region injured was assigned using International Classification of Diseases Ninth Edition primary diagnosis codes. Resource utilization was calculated using the 2008 Department of Defense billing calculator.

Results: Our cohort consisted of 1,337 service members with 2,899 admissions. Three hundred forty-one service members had 670 readmissions. Of rehospitalizations, 64% were for extremity injuries making up 66% of all rehospitalization days. Seventy percent of service members injured had at least one admission for extremity injury. Wound debridement made up 12% of all readmissions, and 92% of these were for extremity injuries. The estimated cost of rehospitalization for extremity injuries for this conflict to date is $139 million.

Conclusions: Extremity injuries have been shown to result in the greatest long-term disability and require the greatest resource utilization during initial treatment. This study demonstrates that they also are the most frequent cause of rehospitalization and require the greatest resource utilization during rehospitalization.

Key Words: Rehospitalization, Combat trauma, Resource utilization.

(*J Trauma.* 2011;71: S98–S102)

The epidemiology of wartime casualties from the current conflicts has been the subject of rigorous evaluation.[1–4] Study of the injury patterns and wounding characteristics from the current conflicts in Iraq and Afghanistan have demonstrated the predominance of extremity wounds in combat trauma with impressive statistics such as 82% of all casualties having at least one extremity injured.[1] Once evacuated, the established resource allocation for treatment in the inpatient environment is 64% of all costs associated with initial hospitalizations are for service members with a primary diagnosis of extremity injury.[3] Also, injured service member outcomes have been investigated with 70% of those service members with an extremity injury as their primary disabling condition found unfit for active duty.[4]

Even with these extensive previous studies, there remains a void of knowledge in the course of combat casualty treatment. The time between initial hospitalization and ultimate disability disposition has not yet been evaluated. This encompasses a period with repeat inpatient episodes, planned and unplanned, as well as outpatient visits with a variety of specialty service care. It has previously been hypothesized that initial inpatient cost requirements for extremity injuries would underestimate the percentage of costs for all inpatient visits borne by these injuries as service members with extremity injuries may require rehospitalization at a disproportionate rate compared with other body regions injured.[3] In addition, patients with multiple injuries may require initial care of head or abdominal injuries, and then long-term care for extremity injuries. This is consistent with several studies of polytrauma in civilian patients which demonstrate that functional outcomes and long-term disability are driven primarily by the lower extremity injury regardless of the presence or severity of other injuries.[5–10] In addition, this principle has been borne out in the disability outcomes where patients had an extremity injury as their primary source of disability at a greater percentage than those who had a primary extremity injury on initial hospitalization.[4] The initial hospitalization may be for head/neck or thoracoabdominal trauma; however, the disability is driven by the extremity injury. Furthermore, rehospitalization for complications is a predictor for poor outcome in extremity trauma,[5] portending higher rates of disability for these service members.

Understanding patterns of injury and resource utilization in this treatment period of rehospitalization may allow for optimization of patient outcomes with benefits for both military personnel and civilian trauma patients with extremity injuries. This study investigates the rehospitalization of combat casualties with a hypothesis that extremity injuries cause the greatest number of rehospitalizations and require the greatest resource utilization.

MATERIALS AND METHODS

Under an institutional review board-approved protocol, the patient population for this study was adopted from a previous large-scale investigation of the spectrum of injuries in the current conflicts which consisted of 3,102 casualties,

Submitted for publication March 10, 2011.
Accepted for publication April 26, 2011.

From the Brooke Army Medical Center (B.D.M., J.R.H.), Fort Sam Houston, Texas; Keller Army Community Hospital (B.D.O.), West Point, New York; and US Army Institute of Surgical Research (J.R.H., J.C.W.), Fort Sam Houston, Texas.
The opinions or assertions contained herein are the private views of the author and are not to be construed as official or as reflecting the views of the Department of the Army or the DoD.
Address for reprints: Brendan D. Masini, MD, Department of Orthopaedics and Rehabilitation, Brooke Army Medical Center, 3851 Roger Brooke Drive, Fort Sam Houston, TX 78234; email: Brendan.Masini@amedd.army.mil.

DOI: 10.1097/TA.0b013e3182218fbc

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
01 JUL 2011	**N/A**	**-**

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER
Rehospitalization after combat injury	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
Masini B. D., Owens B. D., Hsu J. R., Wenke J. C.,	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)	8. PERFORMING ORGANIZATION REPORT NUMBER
United States Army Institute of Surgical Research, JBSA Fort Sam Houston, TX	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release, distribution unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			
unclassified	**unclassified**	**unclassified**	**UU**	**5**	

approximately 27% of the estimated casualties for the time period studied.[1] The subjects were identified from the Joint Theater Trauma Registry (JTTR) that was queried for service members consecutively entered in the database for injuries in Operation Iraqi Freedom and Operation Enduring Freedom from October 2001 through January 2005.[1] The JTTR is a registry that collects information on service members injured in the theater of operations and follows their care until arrival at a military medical treatment facility in the United States. The results of the query were limited to include injured service members treated and evacuated and those classified as died of wounds. Excluded were service members classified as killed in action, returned to duty within 72 hours, or sustaining nonbattle injuries. The remaining cohort approximated those service members wounded in action and not returned to duty.[11]

Data relating to patients' hospital admissions were queried from the Military Health System Executive Information/Decision Support Medical Metrics (M2) database, which is a central repository of detailed clinical, financial, and beneficiary information for Military Health System operations [12]. Data points collected for each of the identified service members were the Diagnosis-Related Group (DRG), International Classification of Diseases 9th edition (ICD9) coding for primary diagnosis, and length of stay (LOS) for each inpatient admission. All admission events for each service member from October 2001 to February 2008 were collected.

The Department of Defense (DoD) uses the DRG prospective payment system for determining the charges associated with inpatient hospitalization. This DRG billing system was accepted for use by Medicare in 1983 to set levels of reimbursement for inpatient admissions[13] and subsequently adopted by the DoD. A DRG is a grouping of ICD9 diagnoses that are similar in resource utilization required during hospital admission. The dollar value billing charge generated in this model encompasses all treatment-related resources for the entire hospital stay including but not limited to surgical costs; radiographs; medications; and physician, nursing, and ancillary personnel support. In this model, the calculated billing charge is equivalent to the resource utilization required for the treatment of injured service members.

The DRG for a particular admission is determined by a grouping algorithm that takes several admission characteristics into account including the patient's primary diagnosis (identified by ICD9 code), secondary diagnoses, surgical procedures, age, gender, and discharge disposition. These data points are extracted from hospital charts by coders, and the DRG is determined independent of the treating physicians. This system responds to complexity of disease or injury by adjusting for disease severity for each group and for LOS.

Our model for determining billing charges was in accordance with the procedures set forth for DoD and Veterans Affairs. This begins with Adjusted Standard Amount (ASA), which is a dollar value specific to each medical treatment facility and based on local wage differences and related medical education costs. To eliminate variation in the calculation of charges for the same injury due to different treatment facilities, the ASA for each of these calculations was standardized to the Brooke Army Medical Center (Fort Sam Houston, TX) rate for fiscal year 2008. Each DRG has a specific ASA multiplier that gives a base rate. That rate is modified in a billing calculator for outlier admissions requiring greater or less resources as determined by the patient's LOS.

The results from the inpatient billing model and the disability benefit calculation were extrapolated to the total current combat-injured population. This was accomplished using available casualty data as of April 2, 2010, which counted 17,011 service members wounded in action and not returned to duty.[14]

Analysis of this data was performed by body region injured according to the criteria described by Churchill.[15] Previous study of this cohort identified an average of 4.2 wounds per casualty, often in different body regions.[1] For this reason, it was necessary to determine a primary body region injured to associate with each set of admission data. The results of searches for DRG and primary ICD9 code for each admission and injury descriptions from the JTTR were used to assign each service member to four groups: head/neck, thorax, abdomen, and extremity. Of note, in this classification, spine injuries are categorized based on the region (head/neck, thorax, or abdomen) that they occur and are not counted as extremity injuries. In addition, pelvis injuries are calculated in the abdominal group. Polytrauma patients were categorized by the primary ICD9 code for the admission as coded for billing by the treating facility. Each admission episode was classified individually to evaluate differences in body region injured which accounted for rehospitalization.

A hospitalization episode was defined as a unique entry in the M2 database for a given service member characterized by dates, DRG, ICD, and LOS data exclusive of any other hospitalization episode. The rehospitalizations analyzed in this study excluded the first two admission episodes of record as these were most often continuous from the date of injury and only identified as separate events in the database due to evacuation from theater.

RESULTS

Of 3,102 casualties in this time period, 1,566 were combat wounded and evacuated from theater. Complete data were available for 1,337 and these were included in this study. A total of 2,899 hospitalizations were identified for an average of 2.2 per service member (range 1–12) with distribution further illustrated in Figure 1. The initial two hospitalizations of each service member were excluded from analysis leaving 341 service members with 670 rehospitalizations. Nine hundred ninety-six patients did not require rehospitalization after evacuation. The 341 service members represent 26% of the cohort requiring rehospitalization due to the severity of their injuries. Twelve percent required multiple readmissions. Sixty-four percent of rehospitalizations were for extremity injuries making up 66% of all rehospitalization days and 67% of all costs (Table 1). Eight of the 10 most common DRGs for readmission were almost exclusively coded for extremity injuries (Table 2).

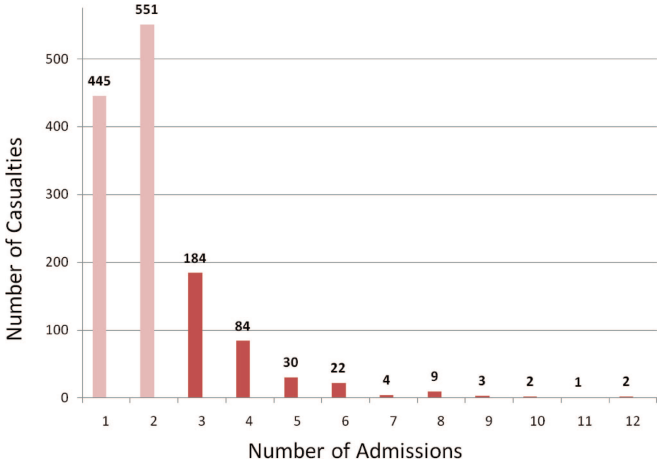

Figure 1. Distribution of combat casualties by number of readmissions.

TABLE 1. Readmission Statistics by Body Area Injured

	Abdomen	Extremity	Head	Thorax	Total
Re-admits	79	432	136	23	670
% Re-admits	12%	64%	20%	3%	
Days	475	3565	1261	94	5395
% Days	9%	66%	23%	2%	
Average	6.01	8.25	9.27	4.09	8.05
Cost	$1,420,485	$11,016,792	$3,494,014	$415,681	$16,346,972
% Cost	9%	67%	21%	3%	

TABLE 2. Most Common Readmission DRG Codes in This Cohort of Injured Service Members

Diagnosis Related Group (DRG) Description	DRG	Number	Percentage	Extremity
Wound debridement & skin graft	217	54	8%	96%
Local excision and removal of internal fixation devises except hip and femur	538	33	5%	100%
Amputation for musculoskeletal system & connective tissue disorders	213	31	5%	100%
Lower extremity & humerus procedures except hip, foot, femur	219	29	4%	100%
Wound debridements for injuries	440	15	2%	93%
Aftercare without history of malignancy	466	14	2%	93%
Other musculoskeletal system & connective tissue operating room procedures	234	14	2%	29%
Other musculoskeletal system & connective tissue diagnosis	256	14	2%	93%
Other ear, nose, mouth & throat operating room procedures	63	13	2%	0%
Postoperative & post-traumatic infections	418	13	2%	100%
Depressive neuroses	427	13	2%	0%

TABLE 3. Most Common Readmission ICD 9 Codes for Initial Hospitalization Episodes of This Cohort

ICD 9 Code	ICD 9 Description	Rehospitalizations (% of total rehospitalizations)
733.82	Nonunion of fracture, Pseudarthrosis (bone)	32 (5%)
998.59	Other postoperative infection	23 (3%)
738.19	Acquired deformity of head; other specified deformity	16 (2%)
997.69	Amputation stump complication	13 (2%)
309.81	Post-traumatic stress disorder	11 (2%)
728.13	Post-operative heterotopic calcification	11 (2%)
997.62	Amputation stump infection	11 (2%)
709.20	Scar conditions and fibrosis	10 (1%)
V55.3	Attention to colostomy	9 (1%)
V58.43	Aftercare for surgery	9 (1%)

Wound debridements were evaluated as a separate group. Greater than 12% of all admissions had debridement DRG codes, and they were among the most common individual DRG codes (440, 287, 266, 265, 264, and 217) assigned. Extremity injured service members were treated in 92% of these debridement hospitalizations. The most common ICD9 codes for rehospitalization (Table 3) show a predominance of extremity injury complication-related diagnoses.

The numbers of patients who were initially admitted for a nonextremity injury, but later were readmitted for an extremity injury, were also evaluated. Of the 527 patients admitted initially for a nonextremity body region injury, 337 (64%) required a readmission. Of the service members who required readmission in this group, 130 (39%) had a primary ICD9 diagnosis of extremity injury for at least one subsequent admission. Of the 810 service members with initial diagnosis of an extremity injury, 555 (69%) required readmission. Of these service members, 103 (19%) were subsequently readmitted with a primary diagnosis of injury to a nonextremity body region.

After 3- to 6-year follow-up of this cohort of 1,337 service members, 70% of patients had at least one admission episode with a primary diagnosis of an extremity injury. The estimated cost of readmissions for extremity injuries in this cohort alone is nearly $35 million.

The total resources for inpatient treatment from time of injury throughout the multiple hospitalizations were $79 million, of which 67% was for extremity injuries. Extrapolating this to the total combat-injured population to date yields inpatient resource utilization of just over $1 billion, of which over $667 million is required for extremity injuries. The estimated cost of rehospitalization to date is $208 million, of which $139 million is required for extremity injuries.

DISCUSSION

The predominance of extremity wounds in combat trauma and the resource burden borne by initial hospitalization for these injuries has been previously investigated.[1–4] These investigations raised the question of the quantity of

resources required throughout the course of care to include subsequent hospitalizations. Potential implications of these data include guiding patient expectations and improving care delivery and optimization of resource allocation to facilitate this care. This extends beyond direct care and also impacts allocation of resources for research and development of new treatment paradigms to facilitate efficient delivery of care in the military managed care environment.

This study had primary findings that 70% of all combat casualties had at least one admission episode with an extremity injury as a primary diagnosis and that extremity injuries require 68% of all resource dollars required for follow-up hospitalizations. The percentage of patients is higher than had previously been reported for rates of admission due to combat trauma from the current conflicts.[3] It approaches the overall incidence of an extremity trauma which was reported as present in 82% of casualties by Owens et al.[2] in 2007. These figures indicate that if an extremity trauma occurs, even in the presence of other serious polytrauma, the chances are very high that the patient will at some point require hospitalization for primary treatment of that extremity injury.

The finding of costs associated with readmission of extremity injuries (67%) is consistent with the findings of Masini et al.[3] in the investigation of initial inpatient resource utilization, where 64% of all resources went toward extremity injuries. It also is similar to the 69% of patients with extremity injury as the primary disabling condition for veterans in the medical board process examined by Cross et al.[4] From these studies of the current conflicts, a trend emerges that extremity trauma requires roughly two-thirds of resources to treat in all phases of care and creates approximately two-thirds of overall disabilities. Outpatient resource utilization has not yet been investigated but could reasonably be hypothesized to also follow this trend. This data could be applied for allocation of resources for clinical support of departments treating these injuries and for research support for combat casualty care.

Wound debridement is among the most common procedures performed on combat wounds of all types, to all body regions, and by all surgical services. This relatively specific diagnosis group is costly and encompasses a surgical procedure during the course of admission. Prolonged hospital stays are often required in patients who require multiple debridements to clear infection or for severely contaminated wounds that are common in wartime blast trauma. In addition, otherwise healthy patients may often be discharged with temporizing wound coverage such as a negative pressure wound closure devise and thus obligate themselves to readmission for definitive wound coverage. The percentage of total debridement admissions attributed to extremity injured patients (95%) far exceeds the frequency of extremity injuries in this population. This indicates that either the extremity injuries are of greater complexity or have greater difficulty healing than injuries to other body regions.

Complications from traumatic injuries are common, particularly among extremity injuries. The most common ICD9 code for readmissions was nonunion of fracture, with infection of orthopedic implants also among the 10 most common. Additional reports of the wartime experience have also demonstrated high rates of complications with extremity trauma such as with open tibia fractures.[16] This is also seen in civilian extremity trauma literature where severe lower extremity injuries can expect high rates of complications and readmissions.[17] A study of civilian firearm injuries, which may most closely mirror a combat injury, demonstrated the significant costs of these injuries and that 26% of the costs of treatment were due to readmission episodes.[18] In addition, readmission for complication of lower extremity trauma has been shown to be an independent predictor of a poor functional outcome.[5] These findings suggest that optimization of management of extremity trauma to reduce complications would have large reductions in both readmissions and resource utilization and likely improved patient outcomes.

The hypothesis that rehospitalization would favor extremity injuries was based on an assumption that patients with multiple injuries, which are common in combat trauma, may initially require care of head or abdominal injuries and also will need care over a longer period of time for extremity injuries. This was evaluated by assessing the crossover of patients from one group to another. The findings were that nearly double the percentage of patients had crossover from nonextremity injuries to extremity injuries as primary diagnoses than patients who went from extremity to nonextremity injuries. This could be predicted based on the civilian trauma literature that describes extremity injuries as a significant factor driving patients' functional outcomes and return to work even with other polytrauma issues.[5,19,20] This is important in directing resources for care. It may be more important for tertiary care military medical treatment facilities within the continental United States to be fully staffed and able to treat and rehabilitate extremity injuries and amputations than in the lower echelons of care, where more of a balance between orthopedic and general surgical trauma capabilities may be warranted. It also indicates that extremity injuries may be underestimated if a model based on initial hospitalization records is used to direct resource allocation.

Limitations of this study include those inherent to its restrospective design including the inability to specifically identify the exact surgical procedures performed on admission or extent of an individual injuries' contribution toward patient resource consumption. Another limitation is the inability to estimate the cost of outpatient treatment and rehabilitation in our system, as these data are not catalogued in this database. Along these same lines, determination of durable medical equipment costs, such as wheelchairs, ambulatory assist devices, prosthetics, and orthotics in our patient population, is not catalogued in a searchable fashion and was unable to be determined. Some civilian studies suggest that prosthetics alone can have a significant long-term cost impact in a young patient.[21] In addition, the military records were the only source used and so there is potential for underestimation of the data from patients who have left the military medical to receive care in the private sector or in the Veterans Affairs system which is a separate entity. The greatest strength of this study is the cohort size and the single data repository kept for inpatient military medical records. Areas of future study may

include evaluating the specific injury and rehospitalization patterns that characterize service members who will likely not be able to continue on active duty to streamline the medical board process and provide realistic expectations for the injured service members.

This study demonstrates that extremity injuries require the greatest inpatient resource utilization beyond initial hospitalization. This is a marker both for increased disability and greater outpatient resource utilization. This study adds weight to the growing body of evidence that combat extremity injuries require the greatest utilization of medical resources in all phases of combat casualty care.

ACKNOWLEDGMENTS

The authors acknowledge JTTR for providing data for this study.

REFERENCES

1. Owens BD, Kragh JF Jr, Wenke JC, Macaitis J, Wade CE, Holcomb JB. Combat wounds in operation Iraqi Freedom and operation Enduring Freedom. *J Trauma.* 2008;64:295–299.
2. Owens BD, Kragh JF Jr, Macaitis J, Svoboda SJ, Wenke JC. Characterization of extremity wounds in Operation Iraqi Freedom and Operation Enduring Freedom. *J Orthop Trauma.* 2007;21:254–257.
3. Masini BD, Waterman SM, Wenke JC, Owens BD, Hsu JR, Ficke JR. Resource utilization and disability outcome assessment of combat casualties from Operation Iraqi Freedom and Operation Enduring Freedom. *J Orthop Trauma.* 2009;23:261–266.
4. Cross JD, Ficke JR, Hsu JR, Masini BD, Wenke JC. Battlefield orthopaedic injuries cause the majority of long-term disabilities. *J Am Acad Orthop Surg.* 2011;19(suppl 1):S1–S7.
5. Bosse MJ, MacKenzie EJ, Kellam JF, et al. An analysis of outcomes of reconstruction or amputation of leg-threatening injuries. *N Engl J Med.* 2002;347:1924–1931.
6. Zelle BA, Brown SR, Panzica M, et al. The impact of injuries below the knee joint on the long-term functional outcome following polytrauma. *Injury.* 2005;36:169–177.
7. Stalp M, Koch C, Ruchholtz S, et al. Standardized outcome evaluation after blunt multiple injuries by scoring systems: a clinical follow-up investigation 2 years after injury. *J Trauma.* 2002;52:1160–1168.
8. Michaels AJ, Madey SM, Krieg JC, Long WB. Traditional injury scoring underestimates the relative consequences of orthopedic injury. *J Trauma.* 2001;50:389–395; discussion 396.
9. Holbrook TL, Anderson JP, Sieber WJ, Browner D, Hoyt DB. Outcome after major trauma: 12-month and 18-month follow-up results from the Trauma Recovery Project. *J Trauma.* 1999;46:765–771; discussion 771–773.
10. Dischinger PC, Read KM, Kufera JA, et al. Consequences and costs of lower extremity injuries. *Annu Proc Assoc Adv Automot Med.* 2004;48:339–353.
11. Holcomb JB, Stansbury LG, Champion HR, Wade C, Bellamy RF. Understanding combat casualty care statistics. *J Trauma.* 2006;60:397–401.
12. Funk W. Military health system data overview. In: *Working Information Systems to Determine Optimal Management (WISDOM) Notebook.* Washington, DC: TRICARE Management Agency, Department of Defense; 2004.
13. U.S. Congress O, Diagnosis Related Groups (DRGs) and the Medicare Program: Implications for Medical Technology—A Technical Memorandum. *Medical Technology and Costs of the Medicare Program*, 1983. OTA-TM-H-17.
14. American Forces Press Service. Casualty data [Department of Defense Web Site]. Available at: http://www.defenselink.mil/news/casualty.pdf. Accessed April 2, 2010.
15. Beebe GW, Debakey ME. Location of hits and wounds. In: Beebe GW, Debakey ME, eds. *Battle Casualties*. Springfield, IL: Charles C. Thomas; 1952:165–205.
16. Johnson EN, Burns TC, Hayda RA, Hospenthal DR, Murray CK. Infectious complications of open type III tibial fractures among combat casualties. *Clin Infect Dis.* 2007;45:409–415.
17. Harris AM, Althausen PL, Kellam J, et al. Complications following limb-threatening lower extremity trauma. *J Orthop Trauma.* 2009;23:1–6.
18. Wintermute GJ, Wright MA. Initial and subsequent hospital costs of firearm injuries. *J Trauma.* 1992;33:556–560.
19. Read KM, Kufera JA, Dischinger PC, et al. Life-altering outcomes after lower extremity injury sustained in motor vehicle crashes. *J Trauma.* 2004;57:815–823.
20. Holbrook TL, Anderson JP, Sieber WJ, Browner D, Hoyt DB. Outcome after major trauma: 12-month and 18-month follow-up results from the Trauma Recovery Project. *J Trauma.* 1999;46:765–771; discussion 771–773.
21. MacKenzie EJ, Jones AS, Bosse MJ, et al. Health-care costs associated with amputation or reconstruction of a limb-threatening injury. *J Bone Joint Surg Am.* 2007;89:1685–1692.

